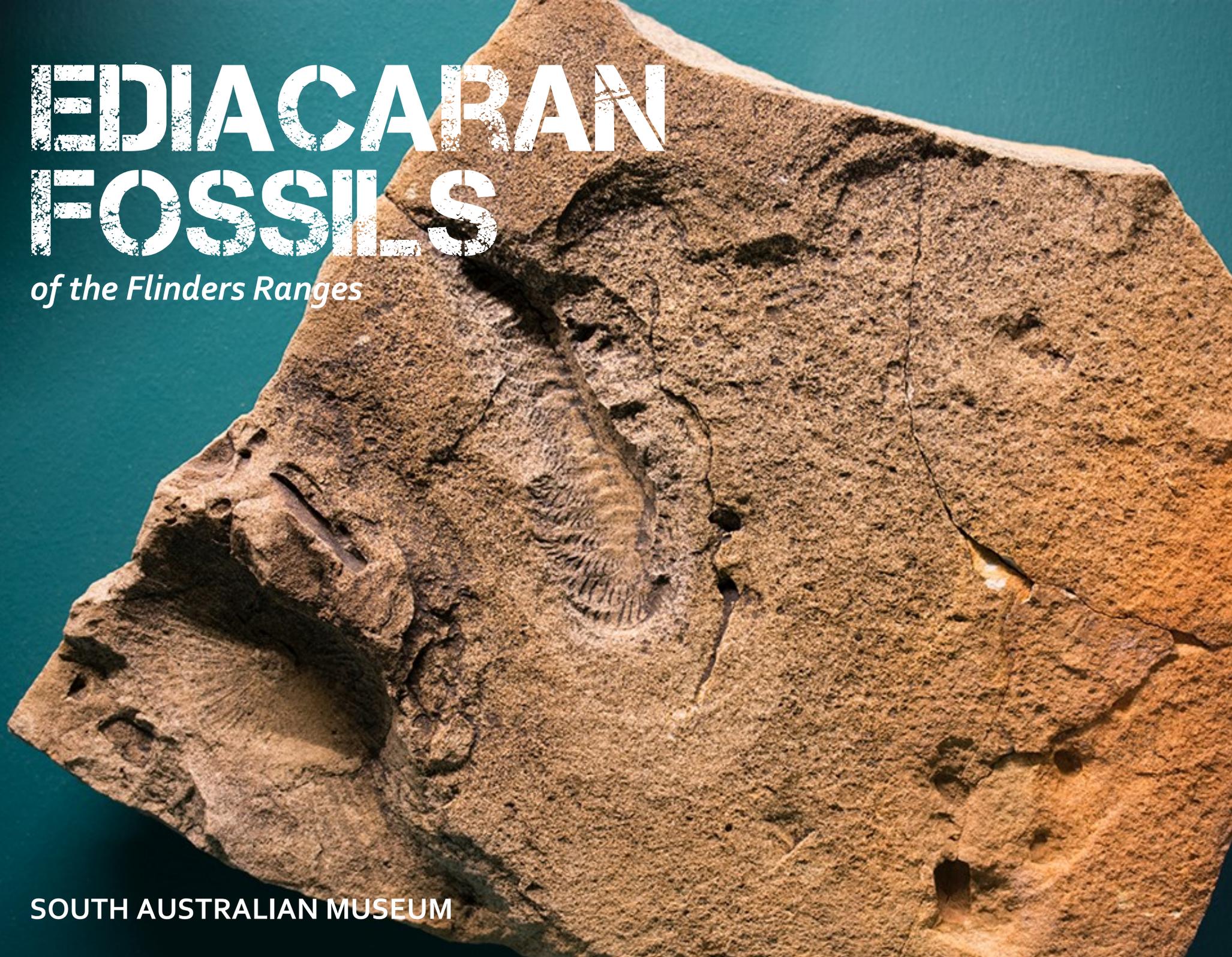


# EDIACARAN FOSSILS

*of the Flinders Ranges*

SOUTH AUSTRALIAN MUSEUM





This educational resource about the Ediacaran fossils of the Flinders Ranges is published by the Department for Education in collaboration with the South Australian Museum. We acknowledge the expertise and resources provided by the Museum's educators and palaeontologists.

We acknowledge and celebrate people from all Aboriginal and Torres Strait Islander nations who have lived on these lands for tens of thousands of years, particularly the Adnyamathanha people of the Flinders Ranges and Kaurna people of the Adelaide Plains, and stand together with them to help share knowledge, culture, understanding and respect.



**Government of South Australia**  
Department for Education



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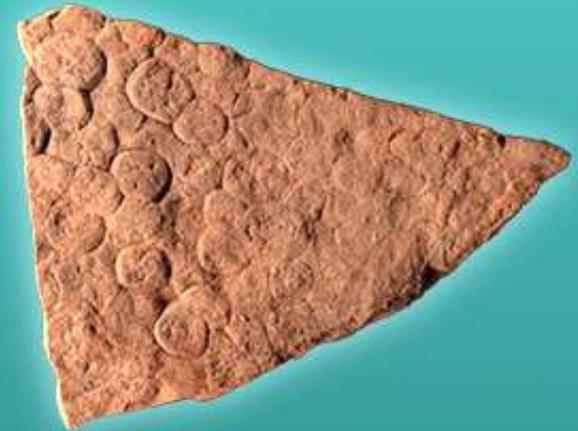


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# EDIACARAN FOSSILS

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Dr Jim Gehling, Palaeontologist  
Video Dur: 1:46

*The discovery of*

# EDIACARAN FOSSILS

in the *Flinders Ranges*, South Australia

is one of the most significant scientific findings made in recent history.

# THE FOSSILS

*that were found...*

reveal a community of organisms living on the seafloor *some 600 million years ago.*

*These **Ediacaran** organisms show evidence of feeding, movement and reproduction, making them the first known **complex life** on Earth.*

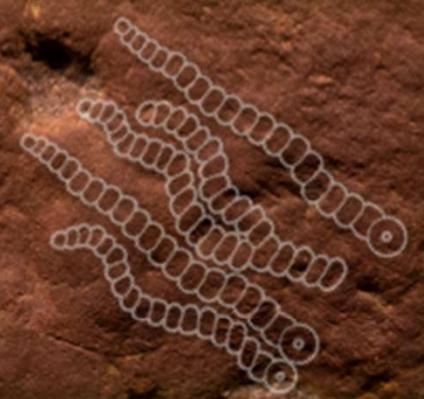
*Some of these are similar to animals that are found today, like worms and **arthropods** ... but others are **unique** and bear no resemblance to current life forms.*



# *The existence of* **EDIACARAN FOSSILS**

**supports Charles Darwin's theory of evolution, as they provide fossil ancestors for the Cambrian animals with hard external parts. This discovery also triggered the creation of a new Geological time**

**the  
Ediacaran period.**



## FOSSILS

are the traces or remains of ancient animals or plants. When plants and animals die they usually rot away, but sometimes they are buried in mud or other material and are preserved.

*When this occurs, they are called fossils.*



## BODY FOSSILS

are the remains of an organism. The most common body fossils are those from the hard parts of the body like bones, claws and teeth. Plants also leave body fossils such as leaves, wood and flowers.



*Trilobite body fossil:  
Found in the Cambrian period*

## TRACE FOSSILS

are the tracks, trails, footprints and burrows that are left by organisms in sediment that are then preserved when the sediment becomes rock. They are the preserved evidence of an animal's behaviour, rather than the animal itself.





**FOSSILS** are  
important as **THEY**  
**PROVIDE A PHYSICAL**  
**RECORD** of  
**EVOLUTION**

*From them,  
we can learn  
about the  
changes that  
have taken  
place in the  
plant and  
animal  
kingdoms.*



Geologists also use fossils to date rocks. Geologists can tell the age of a fossil through a variety of **radiometric dating** techniques.

The breakdown of **radioactive isotopes** of certain elements, such as carbon, uranium and potassium takes place at a known rate, so the age of a rock or mineral containing these isotopes can be calculated.

# EDIACARAN FOSSILISATION

*The processes by which Ediacaran fossils were preserved are of great curiosity to scientists because soft-bodied organisms would not normally fossilise.*

*In the Flinders Ranges, the Ediacaran fossils are found on sandy seafloor beds that were deposited by storm action and strong ocean currents.*

*Today, soft-bodied organisms almost never fossilise in these conditions but it might have been the presence of a microbial mat (organic rich seafloor sediment) that aided their preservation.*

*The mat would have stabilised the organisms allowing their impressions to be preserved.*



# EDIACARAN FOSSIL DISCOVERY

*In 1946*, a geologist, Reg Sprigg visited the Ediacara Hills in the Flinders Ranges. On the bases of sandstone slabs, he found disc-like impressions that looked like jellyfish. Further investigation led him to believe that these fossils were evidence of the oldest animal life on Earth. He published his findings in two papers in 1947 and 1949.

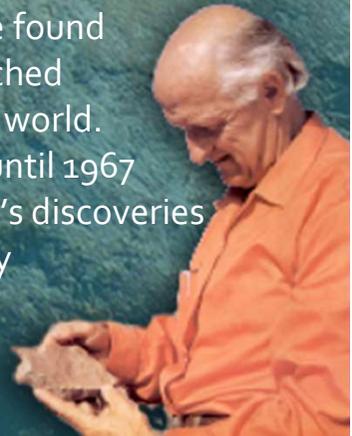


*At the time, many geologists did not believe that soft-bodied organisms could be preserved as an impression in sandstone.*

Reg Sprigg, 1946



Reg Sprigg's claims led to much debate as similar fossils were found and researched around the world. It was not until 1967 that Sprigg's discoveries were widely accepted.



# EDIACARAN FOSSIL DISCOVERY

## FOSSILS OF THE EDIACARA BIOTA

*have been found on every continent except Antarctica.*

Apart from South Australia, the five other most significant sites are found in the United Kingdom, China, Namibia, Newfoundland and Russia.

*Namibia*



*Russia*



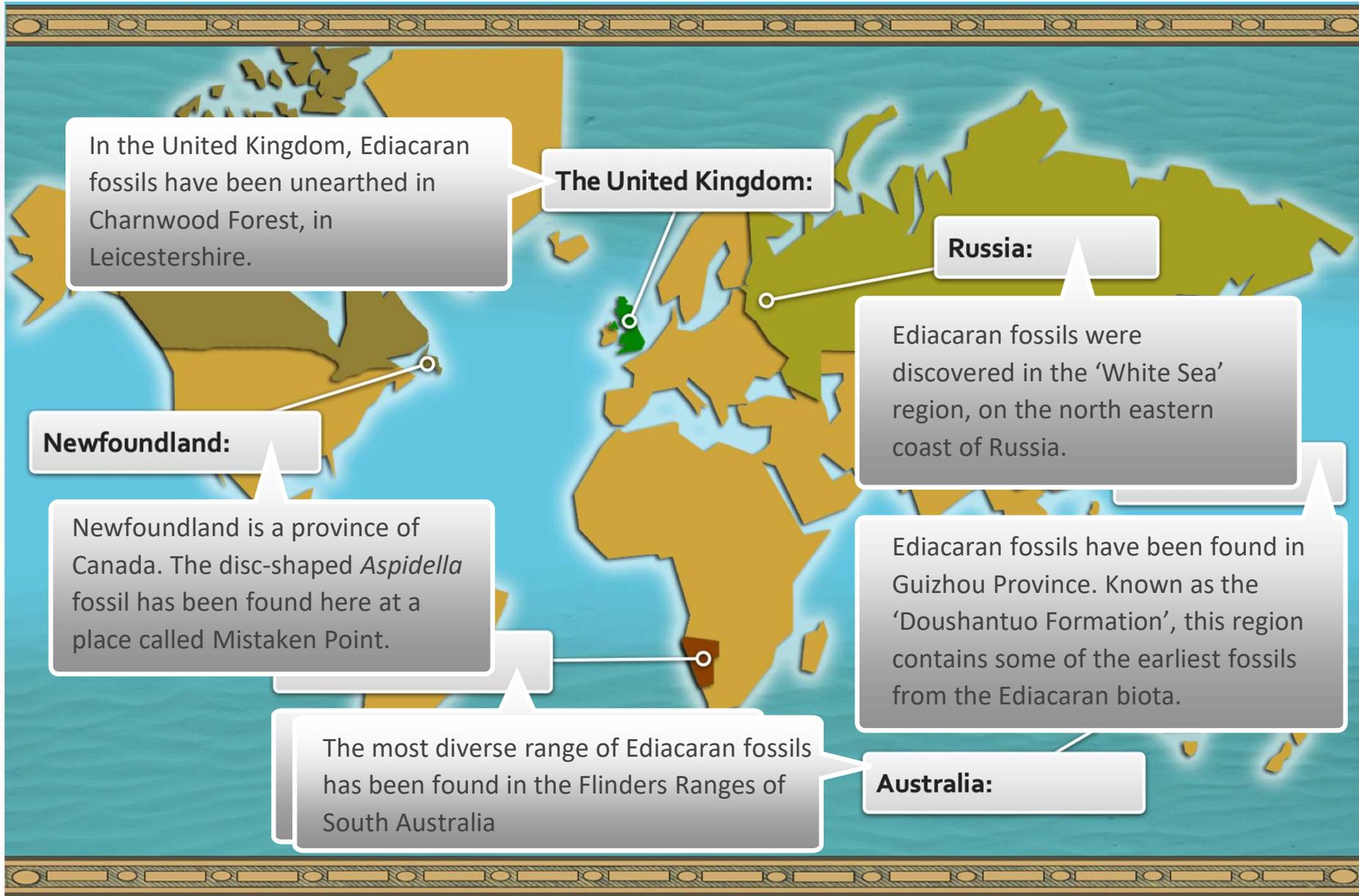
*Canada*



### *Scientists*

in these countries all developed their own theories about these specimens.

## World Map : Countries where Ediacaran fossils have been found





## *The Ediacaran period*

is the last geological period of the Neoproterozoic Era and immediately precedes the Cambrian period.

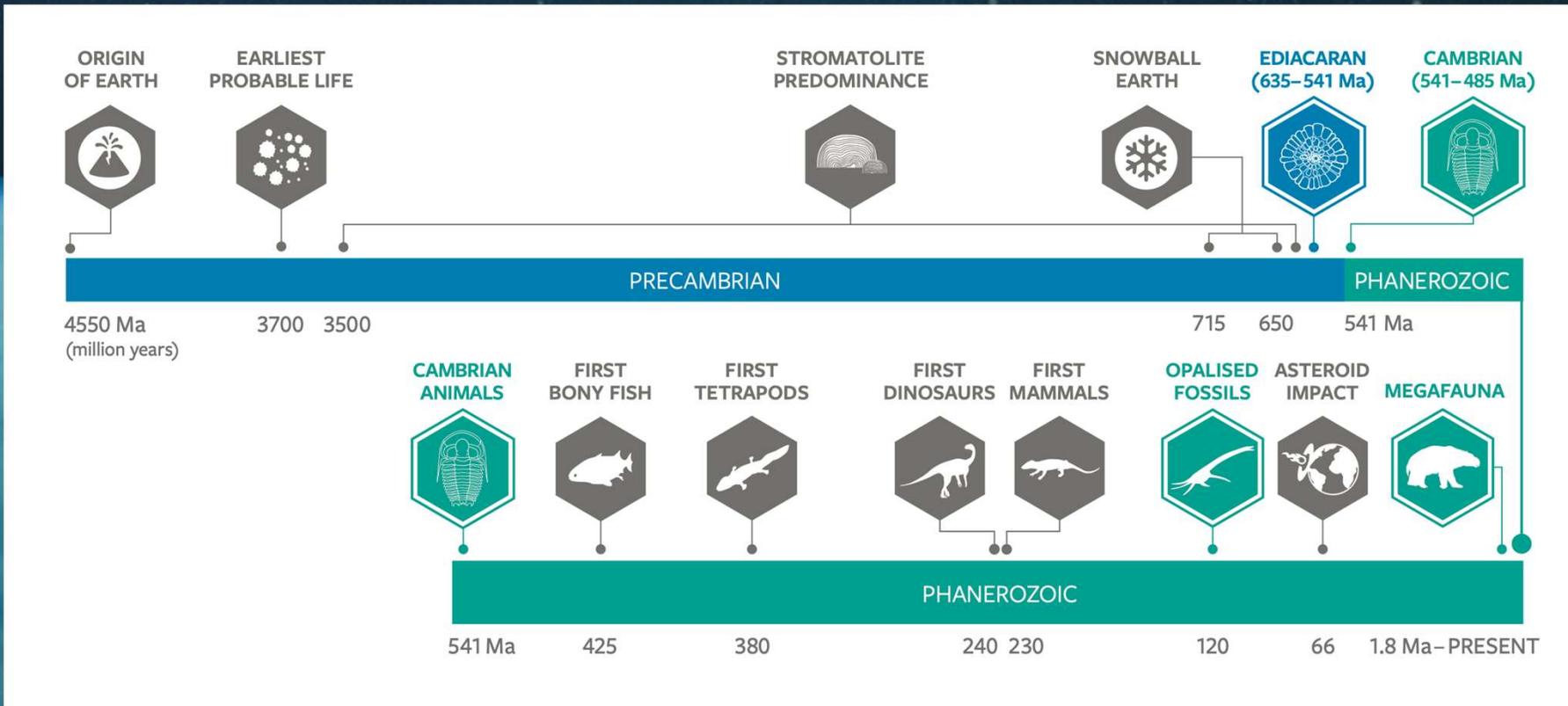


# EDIACARAN PERIOD

*The Ediacaran period begins at the end of a major period of ice coverage on the planet, ..... "Snowball Earth".*

During this "Cryogenian" period, *635 million years ago*, scientists believe that most of the landmass was clustered around the Equator, *ice covered the planet surface and the Earth was almost frozen solid.*

# EARTH'S TIMELINE



*In Ediacaran time, some 35 million years later, the environment was continually changing.*

As a result of **tectonic action**, the landmasses were constantly changing shape and distribution as they moved across the Earth. Sea levels were rising and falling and the oxygen and carbon dioxide levels in the atmosphere were also constantly changing. There were no plants or animals on the land in Ediacaran time, life could only be found in the sea.

## THE EDIACARAN PERIOD

*was ratified in 2004*, making it the first new geological period **declared in 120 years**. The period covers some 50 million years of ancient time on our planet...from 600 million years ago to about 542 million years ago.

Golden Spike

Geological  
Timeline of SA

In 2004, the International Commission on Stratigraphy placed a *Global Stratotype Section and Point (Golden Spike)* in rock strata at the Flinders Ranges.

This is the first “Golden Spike” to be defined in the southern hemisphere.



The Ediacaran **Golden Spike**

is the point in layered sedimentary rocks that *marks the place where rock and time meet.*

All rock strata and fossils above this point and anywhere on Earth is described.

## **SOUTH AUSTRALIAN GEOLOGICAL RECORD**

*South Australia's Geological record provides fossil evidence about the history of life from the following time periods.*

### ***Quaternary (0-2.6 Ma) millions of years***

Fossils of our mega-fauna of extinct marsupials, reptiles and birds, come from river sediments, salt lakes and caves.

### ***Tertiary (2.6-65 Ma)***

Marine fossils, including shellfish, shark teeth and whale bones are common in limestones of the east and west Mt Lofty Ranges and on the Nullarbor plains. Ancient sand and clay deposits preserve broad-leaf plant fossils.

### ***Cretaceous (65-145 Ma)***

During the age of dinosaurs, marine reptiles, molluscs and echinoderms record extinct animals from the great inland, Eromanga Sea.

### ***Triassic (200-250 Ma)***

Coal deposits were formed in inland basins; oil and gas were trapped in rock formations deep down in north-eastern South Australia.

### ***Permian (250-300 Ma)***

South Australia was scoured by ice when Australia was still joined to Antarctica.

### ***Cambrian (490-542 Ma)***

The oldest animal fossils with mineral skeletons, and the first reefs built from sponges and corals, are preserved in rocks of southern and northern South Australia. This was the famous "Cambrian explosion" of life in the ocean.

### ***Ediacaran (542-635 Ma)***

As displayed in this gallery, fossils of the Ediacaran biota, the first large soft bodies animals and plants were preserved in rocks of the Flinders Ranges.

### ***Cryogenian (635-800 Ma)***

During a series of ice ages from 800 to 635 million years ago, stromatolites and microfossils were present, but there was little evidence of larger life forms.

# FLINDERS RANGES

***The Flinders Ranges*** are South Australia's largest mountain range, beginning about 200 km north of Adelaide and ***stretching for over 430 kilometres***. The Flinders Ranges are composed of ***rock strata*** which ***has recorded Earth's history from 870 - 500 million years ago to today***.



The rock formations forming Kangaroo Island and the Mt Lofty Ranges stretching from Cape Jervis on the Fleurieu Peninsula in the south to Clare in the mid-north of South Australia, are a continuation of the Flinders Ranges.

# FLINDERS RANGES

*Geologists refer to this roughly 600 km long series of ranges as the Adelaide Rift Complex.*

It had its origins in a Red Sea-like rift valley some 800 million years ago, opening to an "ocean trough" that filled with sedimentary formations. The oldest of these rock formations can be seen today in the Arkaroola Sanctuary and the Willouran Ranges of the far-northern Flinders Ranges. Together they preserve a total thickness of 10-20 kilometres of sedimentary rock formations.

Throughout time, the sediments in the Flinders Ranges have been faulted, folded and deformed and basically concertinaed. The **topography** that we see today is the direct result of erosion from water and wind. The Flinders Ranges today has a semi-arid environment with rocky outcrops and ranges.



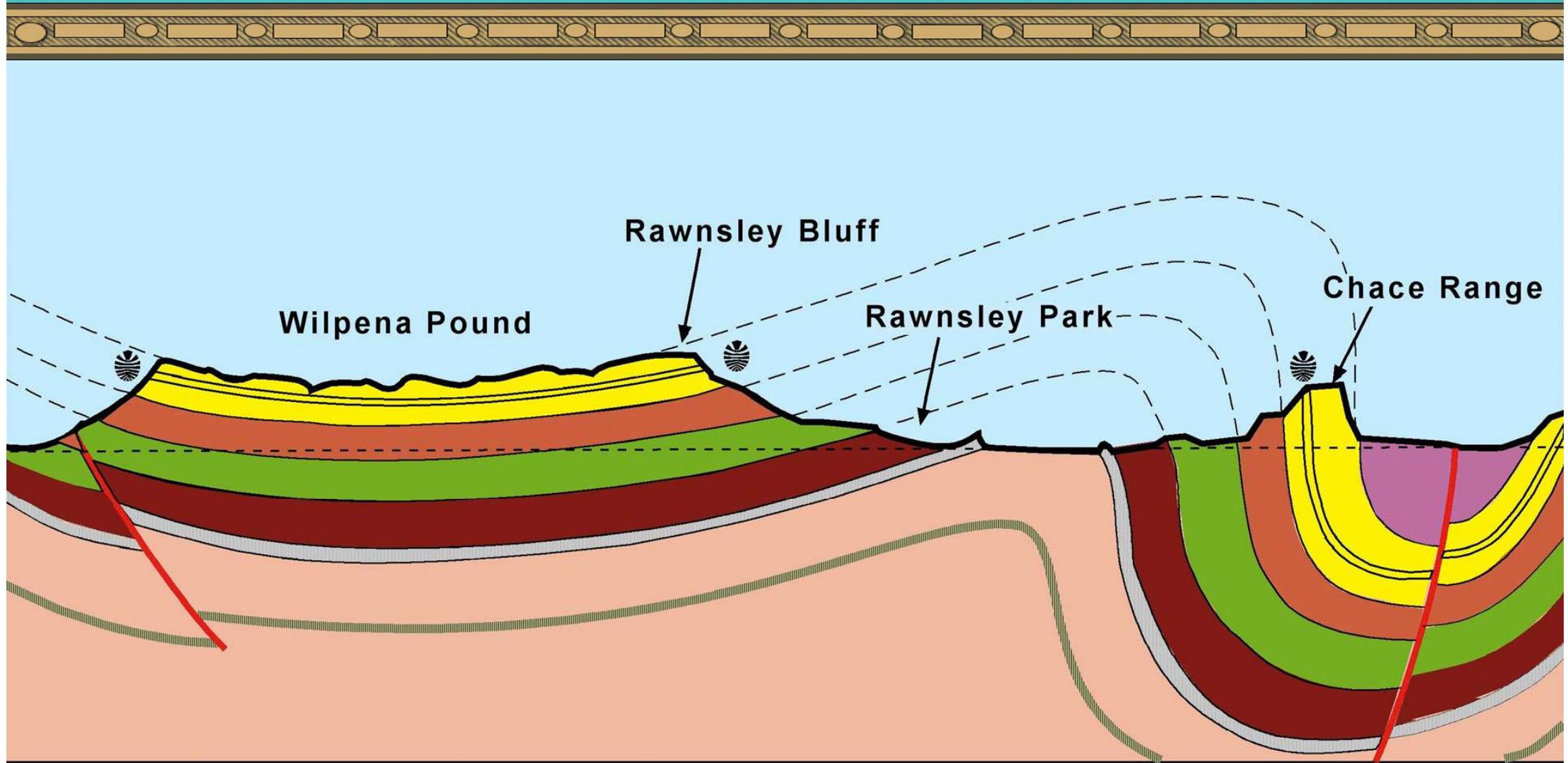
# IN EDIACARAN TIME

*the Flinders Ranges* looked very different.

It was a marine environment in which the earliest known animals lived on the seafloor.

*Ediacaran fossils are found in thin rippled layers within thick bands of the same sandstone that have produced the prominent ridges of Ikara-Wilpena Pound in the central Flinders Ranges.*





NW — SE Cross-section through Wilpena Pound and the Chace Range  
Ediacaran fossils are found in the yellow layer 

# EDIACARAN ORGANISMS...

lived on the seafloor and fed off the microbial mat that lay on the sea bed.

Due to the way they were preserved, Ediacaran animals show no conclusive evidence of a mouth or a gut.

They also had no means of protection, unlike arthropods which had stiff exoskeletons to protect them against predators.



*Ediacaran animals*



*were small*



*soft-bodied marine creatures,*



*with most of them*



*being less than*



*10cm*



*in length.*

# EVIDENCE *of* MOVEMENT



Dr Felicity Coutts  
Video Dur: 0:23

**MOST EDIACARAN ORGANISMS**  
*didn't move and were fixed to the seafloor.*

However, some fossils found in the Ediacaran rocks of South Australia record the first evidence that animals moved across the seafloor. Markings (trace fossils) have been found in rocks that show that some animals moved across the seafloor feeding on the organic mats or burrowed just below the surface.



Around 34 species have been identified from the Flinders Ranges. Scientists use the term, 'Ediacara Biota' to identify fossils found in rock layers of this period.



*Kimberella* (kim-burr-el-a)



*Dickinsonia* (dic-in-so-nee-a)

### ***Kimberella* (kim-burr-el-a)**

*Kimberella* is a possible ancestor of gastropods (sea snails) which excavated the seafloor mat to find its food. *Kimberella* crawled along on a muscular foot. Sets of paired scratch marks made by *Kimberella* provide evidence that Ediacaran animals could move.



### ***Dickinsonia* (dic-in-so-nee-a)**

*Dickinsonia* is one of the most common animals among the Ediacara biota of South Australia. Its feeding traces are shown by depressions in the seafloor. It is thought that *Dickinsonia* moved by either muscular action, like a worm or using cilia (microscopic bristles) like living comb jellies today. *Dickinsonia* would settle on a spot on the seafloor, secrete digestive juices and absorb nutrients from the seafloor.



# Key specimens of the

# EDIACARAN

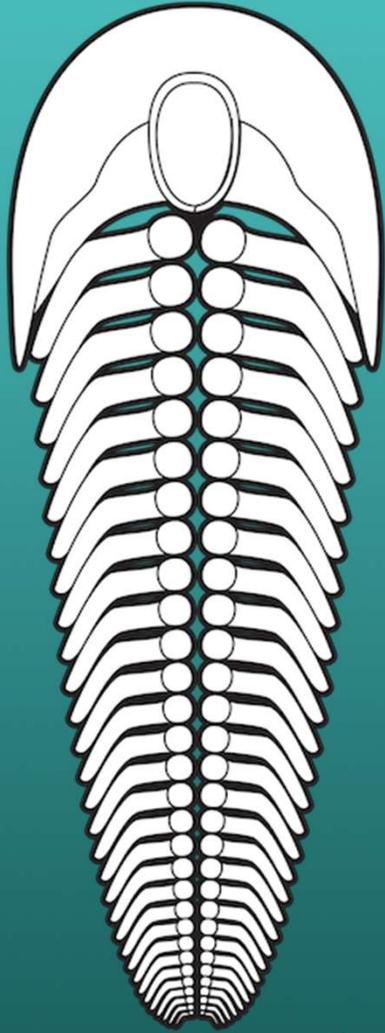
## *Spriggina floundersi* (sprig-ee-na)

*Spriggina* was the first animal with a head. It had a segmented body with a horse-shoe shaped head. It grew like other arthropods and ranged from 3 to 5 cm in length. *Spriggina* is a possible ancestor to shrimps, millipedes and centipedes. In 2017 it was unveiled as South Australia's fossil emblem when more than 3500 South Australians cast their vote in an online poll.

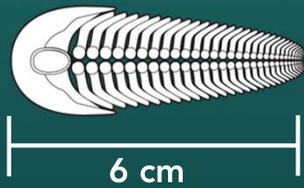
## *Parvancorina minchami* (par-van-co-rye-na)

*Parvancorina* is a small anchor-shaped fossil. It was a bug shaped animal, with a strong **medial** ridge and arc-shaped head. *Parvancorina* looks like other fossil arthropods that have been found in the Cambrian period.

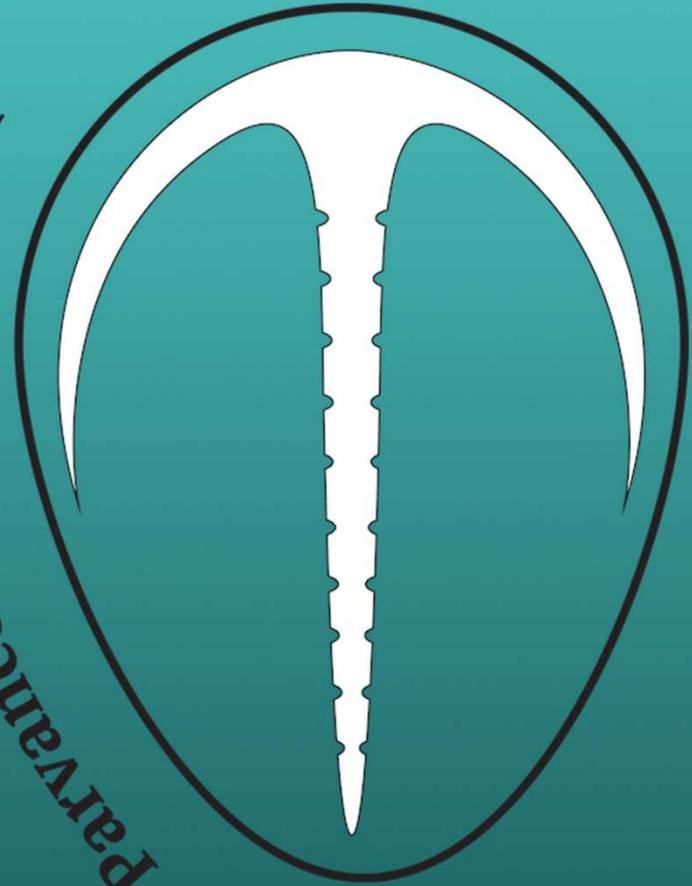
*Spriggina flouderesi*



Life Size



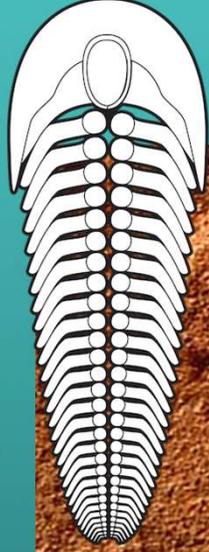
*Parvancorina minchami*



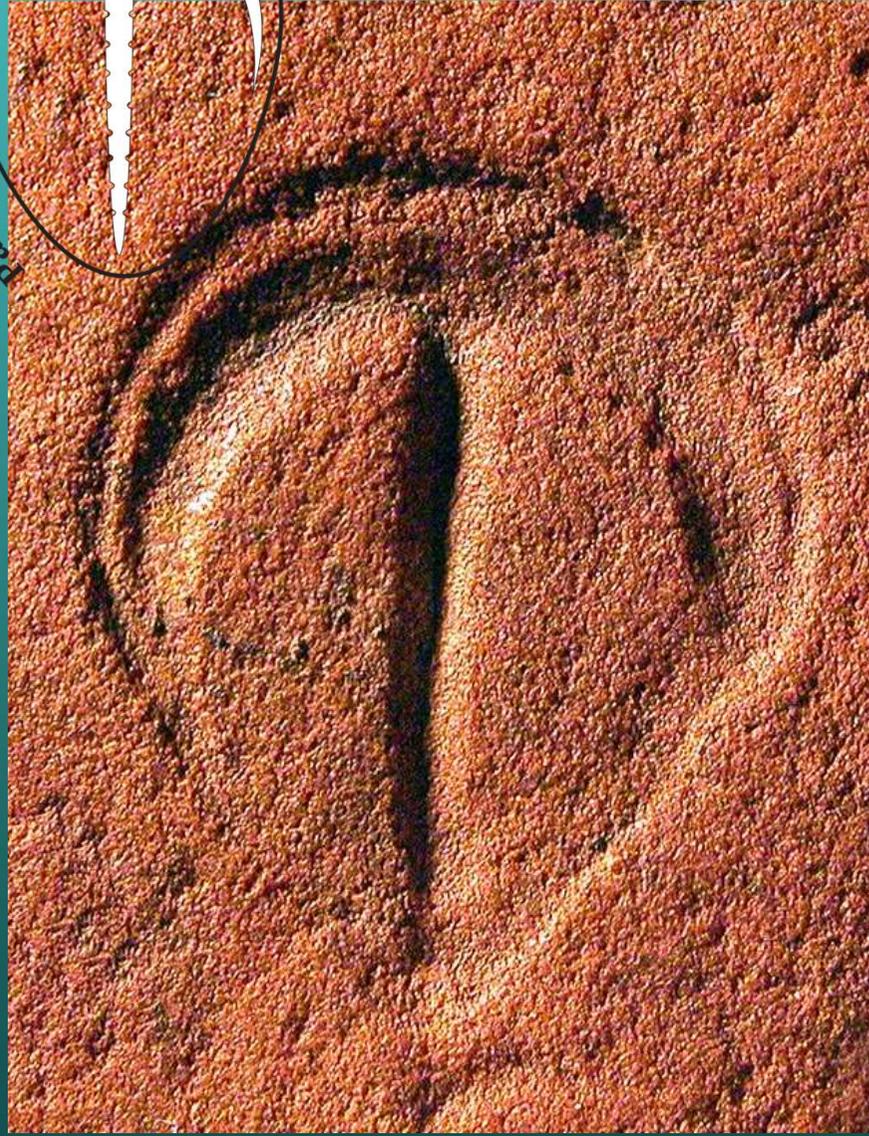
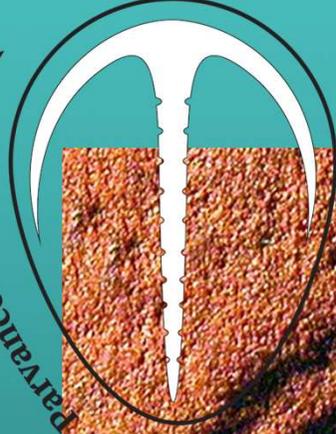
Life Size



*Spriggina flouderesi*



*Parvancorina minchami*



# Key specimens of the

# EDIACARAN

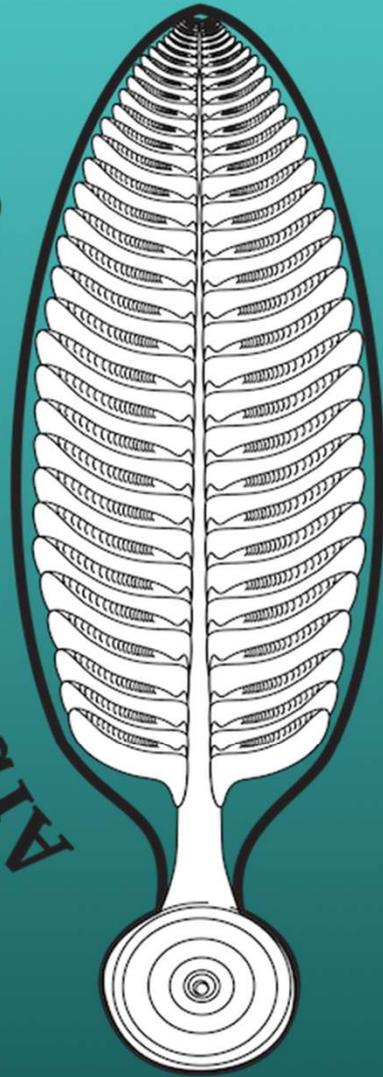
## *Arborea arborea* (ah-bor-ree-ah ah-bor-ree-us)

*Arborea* is a frond-shaped animal, measuring around 15 cm high. It was attached to the seafloor and lived by filtering food from seawater.

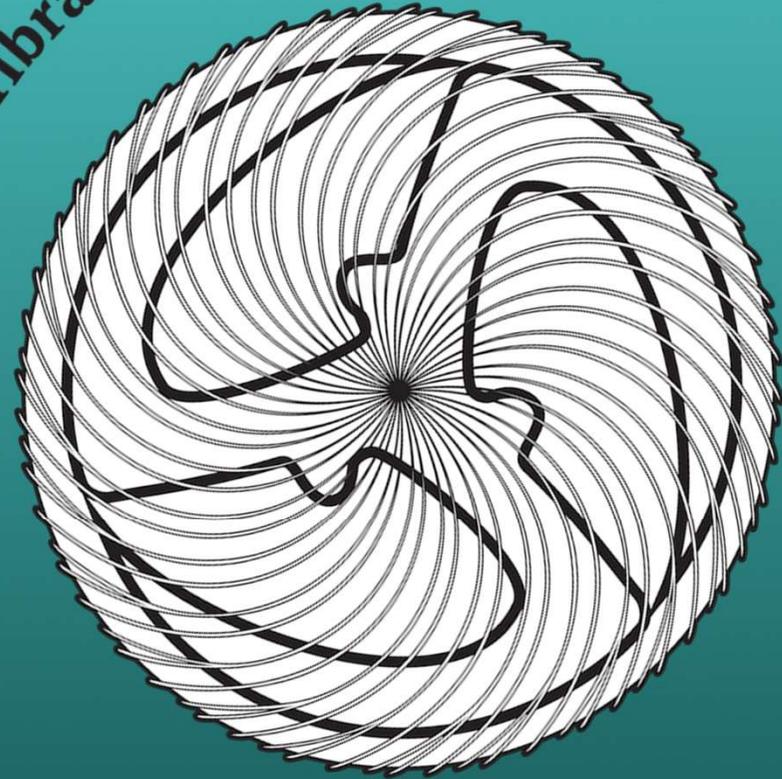
## *Tribrachidium heraldicum* (try-brack-id-ee-um)

*Tribrachidium* is a disc with three bent fringed arms. It was a small, rounded three-armed spiral shaped animal. *Tribrachidium* had an unusual body form with three planes of symmetry. *Tribrachidium* had a radius of up to 5 cm and was about 5-10 mm high.

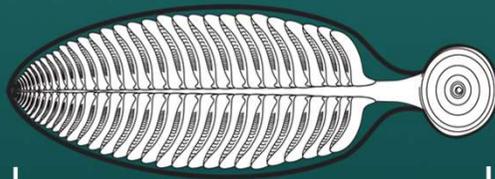
*Arborea aborea*



*Tribrachidium heraldicum*

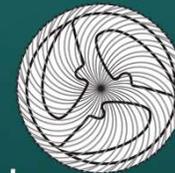


Life Size



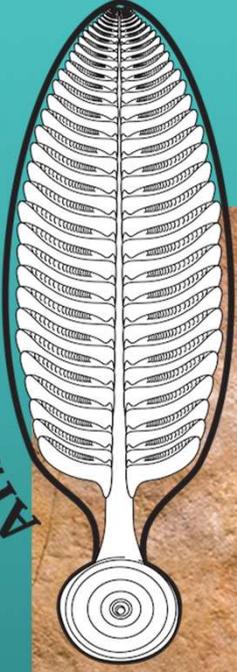
From 1 cm – 84 cm

Life Size

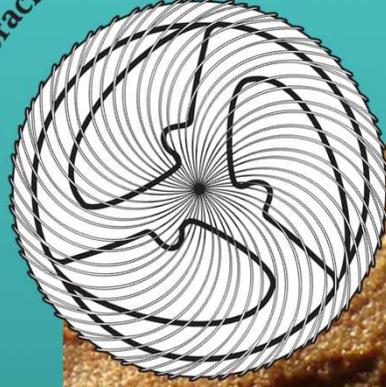


3 cm

*Arborea aborea*



*Tribrachidium heraldicum*



# Key specimens of the

# EDIACARAN

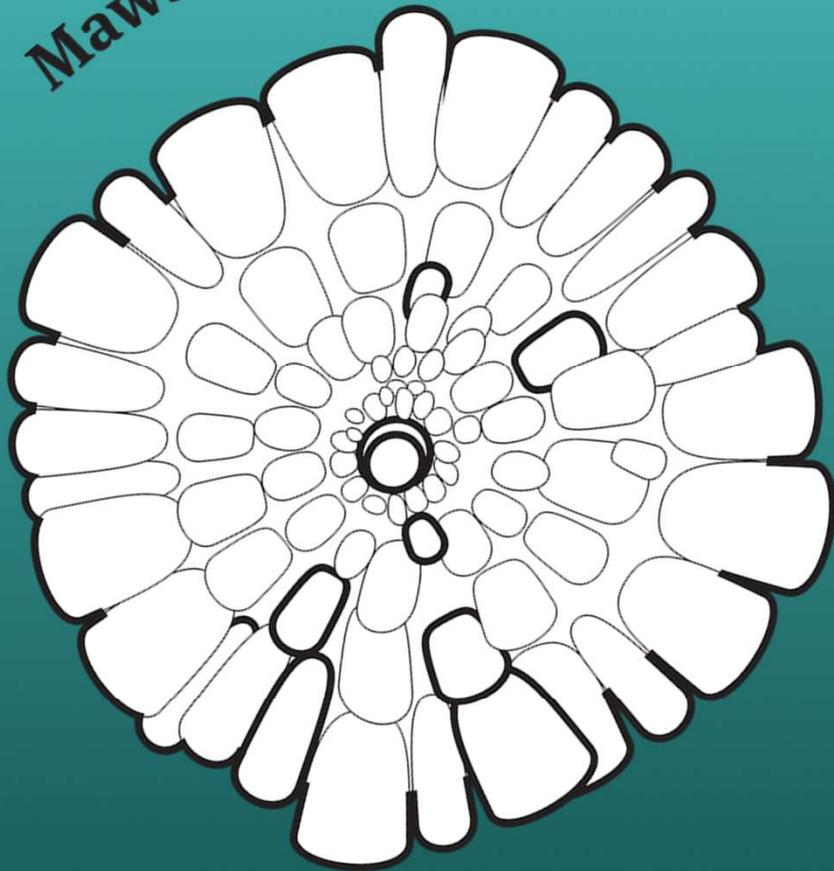
## *Mawsonites spriggi* (maw-son-eye-tees sprigg-eye)

*Mawsonites* is a disc-shaped organism with radial lobes that appears to have buried itself in the seafloor sediment. *Mawsonites* was first thought to be a jellyfish but is more likely to be a form of **sea anemone**.

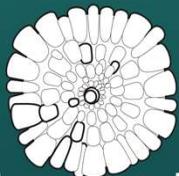
## *Palaeophragmodictya reticulata* (pal-eo-frag-mo-dic-ta)

*Palaeophragmodictya reticulata* was one of the earliest complete sponges with a dome shaped mesh skeleton. Sponges have no muscles, nerve network or internal organs and are the simplest known animals on Earth.

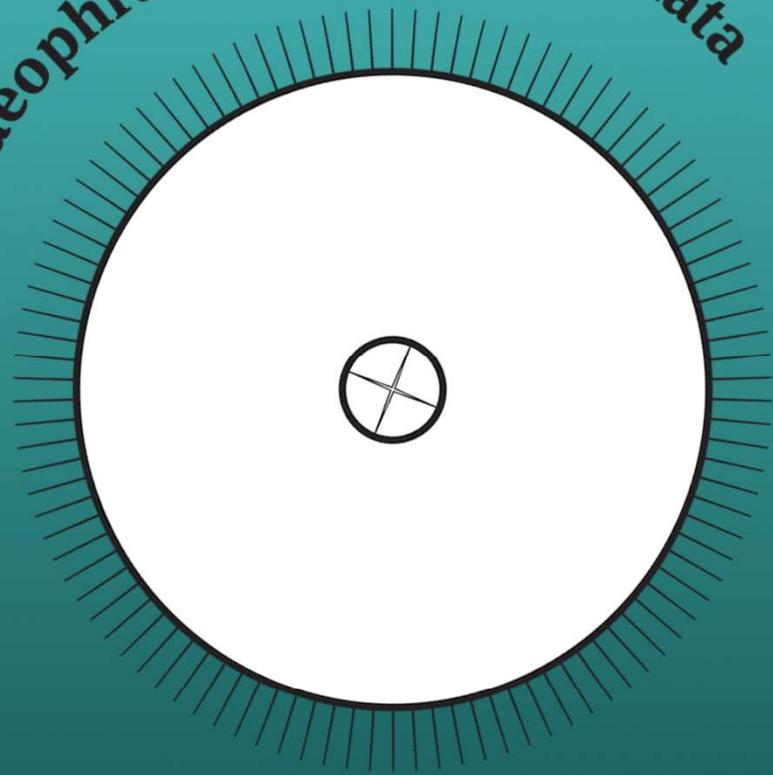
*Mawsonites spriggi*



Life Size



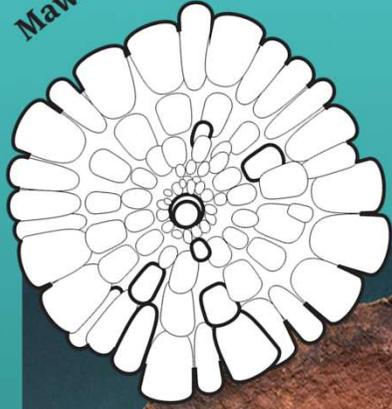
*Palaeophragmodictya reticulata*



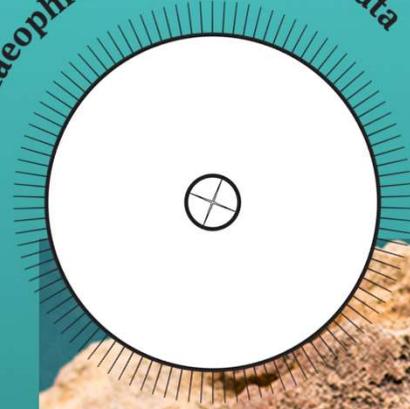
Life Size



*Mawsonites spriggi*



*Palaeophragmodictya reticulata*



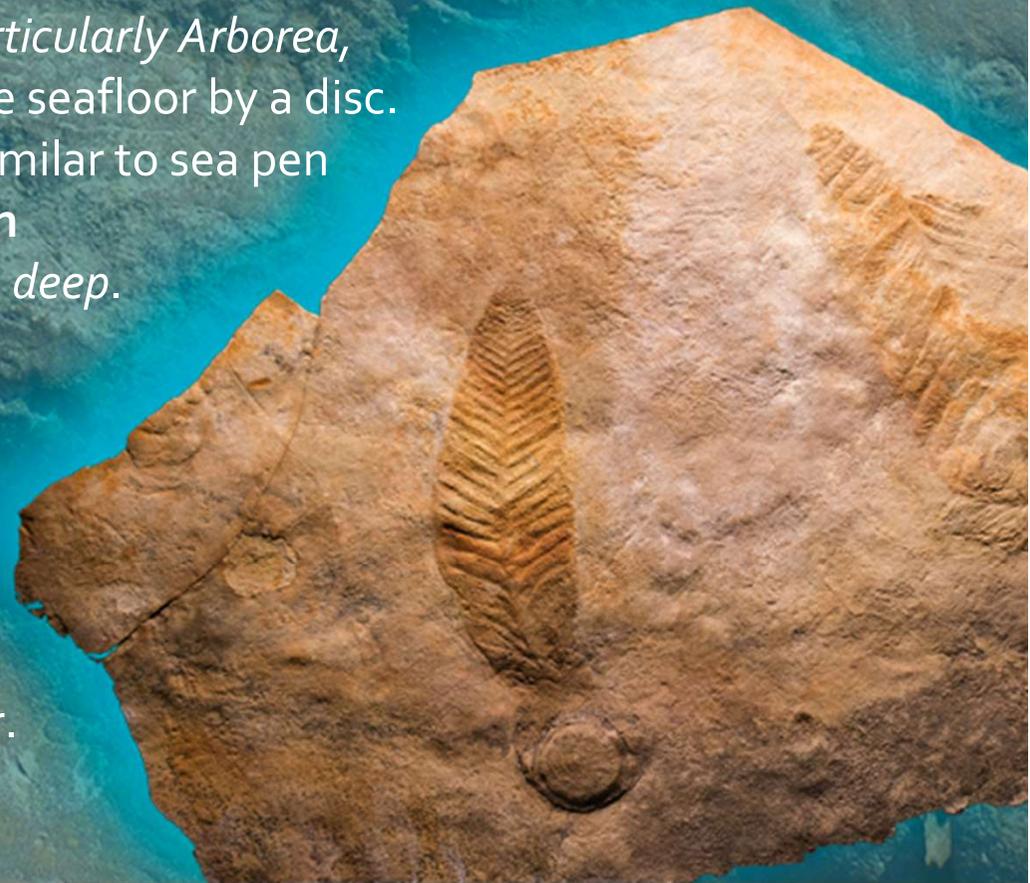
# INTERPRETATION OF EDIACARAN FOSSILS

Scientific debate continues over the interpretation of the Ediacaran fossils.

*Some of the fossils found in the Ediacaran biota, particularly **Arborea**, look like plants.* *Arborea* is a frond attached to the seafloor by a disc. Despite looking like a plant, it is believed to be similar to sea pen animals that live today. **Arborea** fossils have been found in water depths that were at least 200 metres deep.

At this depth no light is present and plants need light to **photosynthesise**.

This is one argument that supports *Arborea* being an animal, another is that plants did not evolve until much later.



# SEA PEN ANIMAL



# How do we know what *Ediacaran organisms* looked like just from impressions found **IN SANDSTONE ROCK?**



Jo Bain, model maker at the South Australian Museum is actively involved in making three dimensional reconstructions of Ediacaran organisms.

**He likens the process of interpreting Ediacaran fossils to interpreting roadkill.**

*"Imagine you have never seen a cat before and someone gives you a mould of one that has been run over and squashed flat. You have road and fur texture, guts that are flattened to one side and bone which pierces the skin, like spikes through the body. If you had never seen a cat before you wouldn't understand the animal's **Bauplan**, how it was able to move, feed or reproduce."*

*"Interpreting Ediacaran fossils is a bit like this."*

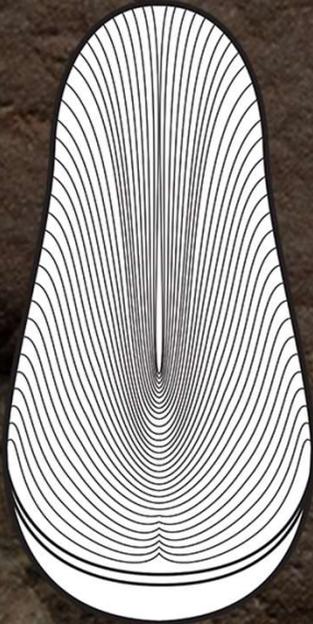
When interpreting fossils, it is important to only look at the existing structures in the fossil and not to make any assumptions based on what is currently known about animal **physiology**.



To build an understanding of what these organisms may have looked like, Jo firstly observes the Ediacaran fossil specimens in detail using a microscope.

Through a microscope, he carefully draws and redraws the organisms because each individual fossil may provide new understandings.

For Jo's interpretation of *Kimberella*, he researched over 500 local specimens, even comparing them with other *Kimberella* specimens found in Russia.



*Ovatoscutum*

Jo has attempted to use new technologies, like 3D scanning to support his findings, but drawing by eye is still the best option. This is because the composition of the rock in which the fossils are found doesn't allow for good (accurate) results. After many drawings, Jo makes a plasticine model and then casts it in rubber.

The colourings of his models are conjecture. He bases his colour choices on his research of microbial mats around the world and the colours of existing seafloor life.





*The discovery and interpretation of*

# **Ediacaran fossils**

*is an active science.*



## *Palaeontologists*

from the **South Australian Museum**  
*and across the world*

study these fossils to learn  
more about the early evolution  
of life on our planet.

New findings are occurring all the time  
as scientists publish their research and  
evidence from across the world is debated.



Dr Felicity Coutts  
Video Dur: 1:15

It is extremely important to protect *the Ediacaran fossil site* at the *Flinders Ranges because it is of global significance.*

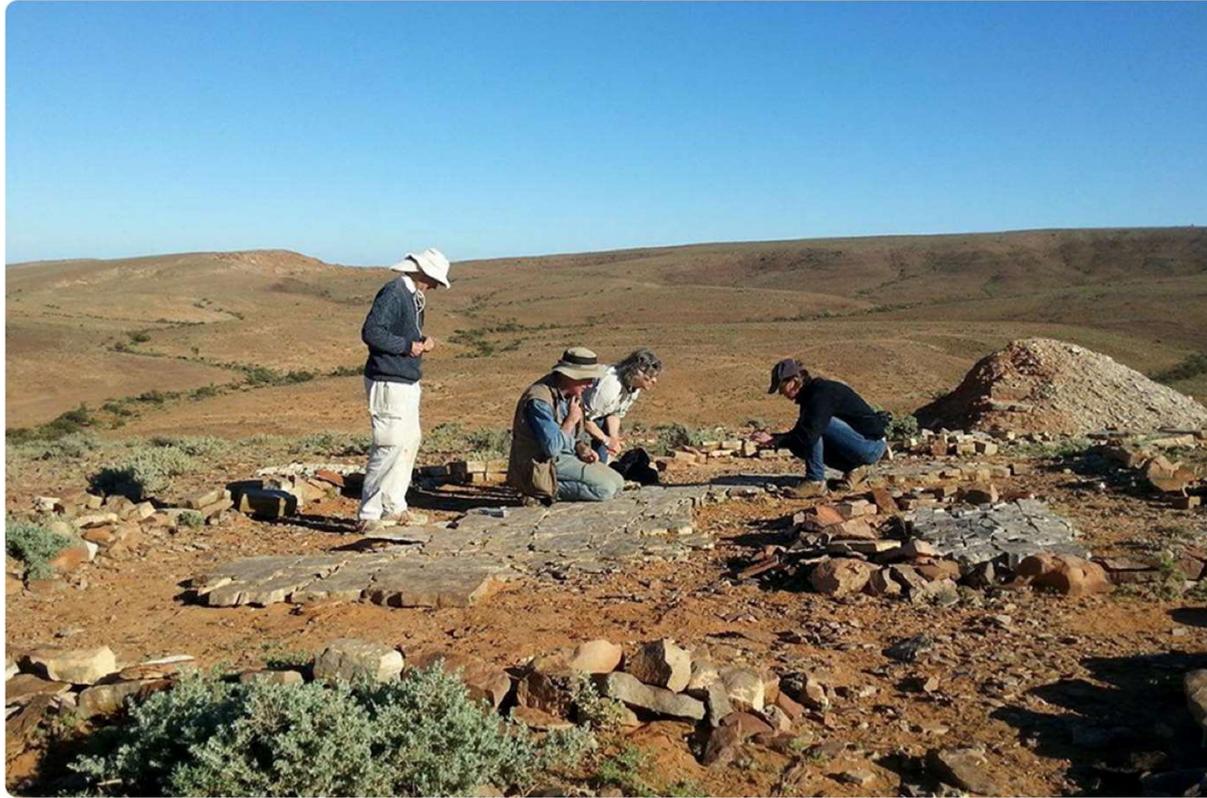
No other fossil site in the world best demonstrates marine life living, moving and feeding across the seafloor. *The Ediacaran fossils in the Flinders Ranges also show one of the largest diversity of fossil species.*

Ediacaran fossils in the Flinders Ranges are preserved in sandstone and its high quartz content protects exposed fossils from weathering. This makes it possible to research the fossils on site.

Protection of the site will allow palaeontologists to continue to learn about these animals in the environment where they were found.



*Field work*



South Australian Museum researchers on site in the Flinders Ranges.

***Field work***



Working on site.

***Field work***



South Australian Museum researchers discussing fossil finds

## *Field work*



Tape is used to mark fossil locations, this enables them to be studied without removing them from the site.

*Field work*



Using chalk to identify the fossil.

## ***Field work***



Evidence of *Dickinsonia* movement is marked with chalk.

***Field work***



Using a basic kitchen brush to clean the fossil.

***Field work***



Photographing the fossil.

## *Field work*



A scale is used to indicate the size and direction of the fossil when photographing.

## *Field work*



Putty is used to obtain an impression of the fossil.  
Putty allows you to see finer details.

***Field work***



Putty impression of *Spriggina*.

***Field work***



Taking moulds of the fossils for later research.

## *Field work*



Plasticine is used to circle the fossil to create a boundary when creating a mould.

***Field work***



Creating a latex mould.

*Field work*

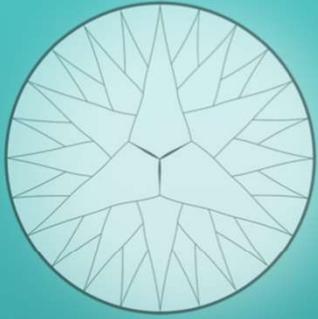


Exposed sea bed.

***Field work***



Researchers discussing their finds.



# THE SOUTH-AUSTRALIAN MUSEUM



**Patterns of Life**  
Most animal bodies grow using radial or bilateral symmetry.

**Patterns of Life**  
Most animal bodies grow using radial or bilateral symmetry.



Visit the South Australian Museum  
Video Dur: 0:31



# Glossary OF TERMS

## **ARTHROPODS**

Arthropods are invertebrate animals of the phylum Arthropoda, such as an insect, spider, or crustacean.

## **BAUPLAN**

Bauplan is a general structured body plan of an animal or plant.

## **COMPLEX LIFE**

Complex life includes animals that are made up of more than one cell and that require atmospheric oxygen for their growth.

## **EDIACARAN**

The Ediacaran period is a geological measurement of time. It is the last geological period of the Neoproterozoic era.

## **EXOSKELETON**

An exoskeleton is a rigid external covering for the body found in some invertebrate animals.

## **MEDIAL**

Medial or 'medial plane' is the midline of the body.

## **MICROBIAL MAT**

A microbial mat is a layered sheet of microorganisms that grows on the seafloor in certain conditions.

## **ORGANISM**

An organism is an individual plant or animal, or a single-celled life form.

## **PALAEONTOLOGIST**

A palaeontologist is a scientist who studies fossils.

## **PHOTOSYNTHESISE:**

Photosynthesis is the process by which plants use sunlight to obtain nutrients.

## **PHYSIOLOGY:**

Physiology is the study of the way living organisms or bodily parts function.



# Glossary OF TERMS

## ***RADIOACTIVE ISOTOPES***

Radioactive isotopes are isotopes that have an unstable nuclei that decompose. Radioactive isotopes release energy or particles until they reach a stable form.

## ***RADIOMETRIC DATING***

Radiometric dating is a method of dating geological specimens.

## ***RATIFIED***

Ratified is to confirm or formally approve something.

## ***ROCK STRATA***

Rock strata is a layer of sedimentary rock or soil with consistent characteristics that distinguish it from other rock and soil layers.

## ***SEA ANEMONE***

Sea anemones are any sedentary marine animal of the phylum *Coelenterata*. They have a columnar body and one or more circles of tentacles surrounding the mouth.

## ***SNOWBALL EARTH***

The "Snowball Earth" theory was created by Brian Harland in 1964. The basis of the theory is that during the Pre-Cambrian era, the continents resided near the Equator and the entire planet was covered with glacial ice sheets from the Poles to the Equator.

## ***TECTONIC ACTION***

Tectonic action is the movement of land masses based on the theory of plate tectonics - where the lithosphere of the earth is divided into a small number of plates which float on and travel independently over the mantle of the earth.

## ***TOPOGRAPHY***

Topography is the physical features of an area.



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